

# ALE Hydrodynamic Simulations for the National Ignition Facility

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16" x 21"

# ALE Hydrodynamic Simulations for the National Ignition Facility

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## ALE Hydrodynamic Simulations for the National Ignition Facility

The National Ignition Facility (NIF) has begun operation in 2003 as the world's most energetic laser. The new regimes produced by this high-energy facility require advanced simulations to predict the effect of the laser vaporized/fragmented material on the target chamber. We show how advanced ALE techniques for radiation hydrodynamic codes combined with ASCI scale computing facilities are enabling accurate modeling of NIF experiments. A major goal of NIF, and a similar facility under construction in France, the Laser MegaJoule (LMJ), is to demonstrate laser fusion. At both of these facilities, debris and shrapnel from target and diagnostic components strike the final optical elements that the laser passes through prior to entering the large, 10-m diameter, vacuum chambers.



Three dimensional simulation of the material boundaries for a laser heated metallic halfraum at the start of the 1-ns laser pulse.

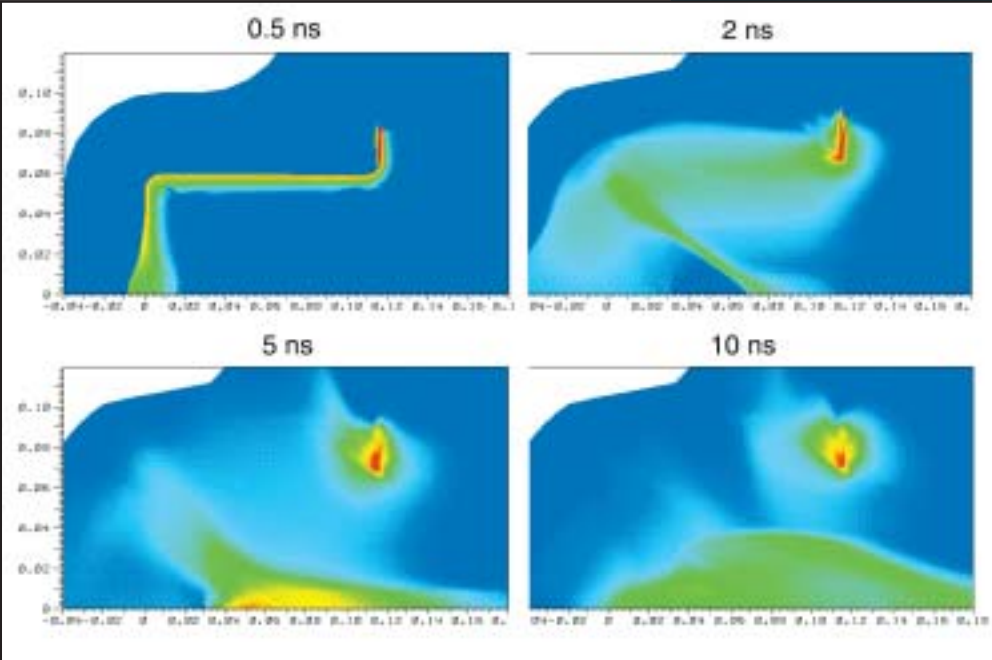
It is important that the lifetime of these optical elements, called debris shields, are not reduced significantly due to impacts by the shrapnel and debris. Simulation of the generation and expansion of debris and shrapnel is an extremely challenging task. Historically, simulation of laser experiments has been restricted to time scales that are of order, or a few times, the laser pulse. To determine the spatial distribution of the expanding debris and

shrapnel we had to modify our numerical techniques to do simulations extending out to many times the duration of the laser pulse. In general, modeling of target/diagnostic components requires 3D simulations, which are only now becoming possible as the ASCI scale computing facilities become available in the US, Japan, France, and other countries.

Our late-time calculations take advantage of the flexibility in the ALE hydrodynamics approach to numerical simulations. During initial expansion of the laser-heated material, the ALE code is run in Lagrangian mode, where the mesh moves with the rapidly expanding ablated material. Later in time, large shear flows lead to significant mesh distortion, which is solved by the mesh relaxation and advection steps in the ALE simulation. Our late-time simulations have an additional complication associated with the mesh expanding to such an extent that parts of the outer boundary come around and collide with other boundary zones that they are not logically connected to on the computational mesh. To avoid these mesh collisions, we have developed a procedure to wrap the target/diagnostic configuration in a very low density "air mesh." The mass contained in this outer "air mesh" is not

sufficient to affect the expansion of the actual components. This technique has allowed us to model a range of different experimental configurations.

As an example, we show a 3D simulation of a metallic halfraum (cylinder with one end closed). In this experiment, the 4 (out of the eventual 192) laser beams currently in operation strike the back wall of the halfraum. We show the material boundaries of the mesh and the initial blowoff of the laser-heated material is visible. This target has a relatively massive flange around the open end of the halfraum. The late-time behavior of the flange is shown after the rest of the halfraum has been completely vaporized. We see that the flange is expanding primarily perpendicular to the incoming laser beam, and the impact of this target on the debris shields is relatively small.



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We show the expansion of the halfraum by giving the density through a slice of the simulation, where only the flange is visible at late times.

